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XI.

MOTION OF ATOMS IN ELECTRICAL DISCHARGES.

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THE application of Spectrum Analysis to the measurement of the approach or recession of a star in a direction directly away or directly toward an observer's eye is generally regarded as one of the greatest achievements of modern science. Experiments upon the oscillatory discharge of electricity led me to reflect whether the method which has been used in star observation might not be employed to test the question whether the atoms of the metals of the terminals between which the oscillatory discharge passes are conveyed to and fro by the oscillatory discharge, or whether they are shaken, so to speak, by the discharge, so that they emit to the ether the ripples which appeal to our senses as light and heat. No mention is made here of a convection effect which would take place too slowly to give a spectroscopic effect.

After I had made the experiments which I will shortly describe, and while I was in doubt whether to publish my results, a paper by Prof. J. J. Thomson, Director of the Cavendish Laboratory, Cambridge, England, appeared in the August number of the Philosophical Magazine (1890), "On the Velocity of the Transmission of Electric Disturbances," which contains the following passage: "The very rapid rate with which the electric discharge is propagated through a rare gas compels us to admit that the electricity is not carried by charged atoms moving with this velocity. For if it were, then if the discharge were to take place in air at atmospheric pressure between two parallel plates one centimeter apart, charged to a potential difference of approximately 30,000 volts, the kinetic energy which would have to be communicated to the atoms to make them move with this velocity would be greater than the original potential energy of the

charged plates, assuming that the charge on each atom is that deduced from electrolytic considerations."

The unusual dispersion afforded by a Rowland concave grating led me to test this hypothesis, in so far as it relates to the question, Are the molecules of metals carried with the oscillations of electricity between terminals between which the oscillations take place? A circuit of wire giving a suitable value of self-induction was arranged in connection with a series of Leyden jars. The time of oscillation was calculated from the well known formula, $t = 2\pi\sqrt{LC}$; in which L is the value of the self-induction of the circuit; C, the capacity of the Leyden jars. Preliminary examination of the electric spark taken through this circuit with a revolving mirror showed that the discharge was an oscillatory one. Two different values of self-induction were employed. One gave the duration of a double oscillation $t = .0000003$ of a second; the other gave $t = .0000024$ of a second.

If we denote by V the velocity of light, λ and λ_1 wave lengths, δ the speed of approach of the atom, we shall have $\lambda_1 = \lambda\left(\frac{V}{V+\delta}\right)$.

The distance across which the oscillations took place was six millimeters. Calculation shows that if the iron atoms were conveyed to and fro between the terminals, a broadening of the iron lines in the spectrum would result, which could be readily detected. The broadening might amount to a space equivalent to a whole tenth meter.

The oscillatory spark passed between two iron terminals. One of these terminals was hollow. The hollow terminal was placed in a line perpendicular to the slit of the spectroscope, so that the oscillation of the spark should be toward and away from the slit. If, therefore, the iron atoms moved to and fro with the oscillations of electricity across the air gap, a displacement of the iron lines in the spectrum of the metal would result. There would be both a displacement toward the less refrangible, caused by the recession of the atom, and one toward the most refrangible end of the spectrum, caused by the approach of the atom. The great amount of dispersion afforded by a concave grating of 20,000 lines to the inch enabled me easily to detect a movement of $\frac{1}{100}$ of a wave length. I accordingly took a photograph of the iron lines with the terminals in the position I have described, and on the same plate, immediately above this photograph, a comparison photograph was taken with the terminals parallel to the slit. In this case the iron atoms did not make their supposed ex-

cursions away and toward the slit, and therefore no displacement of the spectrum lines was to be expected.

The photographic plate was exposed in the neighborhood of the great H lines. A movable shutter enabled me to expose different portions of the same plate without changing any adjustments of the apparatus. The resulting photographs showed no displacement of the iron lines. The iron lines in the two photographs met exactly, continued in an unbroken line across the double photograph, and were of the same breadth throughout their extent.

The conclusion seems to be a strong one, that the electrical oscillations do not carry the atoms of metals with them in spark discharges. The atom is merely shaken up, and caused to emit the vibrations or subsidiary ripples which appeal to our senses as light and heat, while the electrical waves pass on without conveying the atoms.

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